LOWER DUWAMISH WATERWAY
SLIP 4 EARLY ACTION AREA

ENGINEERING EVALUATION/COST ANALYSIS

Submitted to
U.S. Environmental Protection Agency, Region 10
1200 Sixth Avenue
Seattle, WA 98101

Submitted by
City of Seattle
King County

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weight and carbon-normalized PCB concentrations are shown in Figures 2-11 and 2-8, respectively, and are listed in Table 2-5. Six of the nine cores that were analyzed contained one or more intervals with PCBs greater than the CSL. At these stations, CSL exceedances commonly occurred to a depth of 4 or 6 feet. At most locations, no SQS exceedances occurred below 4–6 feet, although CSL exceedances occurred in the 8- to 10-foot interval at Station SC-02 and in the 6- to 8-foot interval at Station SC-03. The depth of sediments exceeding SQS was bounded in all cores except SC-02. An archived sample from the 10- to 12-foot interval at SC-02 may be analyzed, if needed for design purposes.

Other Chemical Results

Surface Sediment. For the subset of 2004 samples that were analyzed for other SMS analytes, eight subtidal samples were analyzed for all SMS organic compounds; four of these eight samples were also analyzed for all SMS metals (Figure 2-12) (Integral 2004e). Two additional samples (i.e., samples SG06 and SG06FR) were analyzed for all SMS organics and metals because they were field QC samples. The intertidal composite sample (IC01) was also analyzed for all SMS analytes. Except for the field QC samples, only one of these locations (SG16) had detected chemicals other than PCBs at concentrations greater than the SQS (however, PCBs also exceeded the SQS at this location) (Figure 2-10). At Station SG16, BEHP and phenol, as well as PCBs, were slightly above the SQS. In the field QC samples [SG06 and SG06FR (SG41S)], two organic chemicals, as well as PCBs, were greater than the SQS or CSL (Figure 2-12). No other metals or organic chemicals exceeded the SQS.

Subsurface Sediment. Other detected chemicals that exceeded the SQS or CSL in subsurface sediment included mercury (seven samples with exceedances) and silver (one sample) (Table 2-6). All metals exceedances were in samples that also had PCBs greater than the SQS or CSL except for the 6- to 8-foot interval at Station SC04. Other than PCBs, there were no detected organic chemicals in subsurface sediment samples that exceeded the SQS or CSL (Integral 2004a).

Comparison of Historical and 2004 PCB Results

When the surface PCB concentrations from 2004 are compared with historical data collected between 1990 and 1998, it is evident that PCB concentrations in surface sediments in many areas of the slip are less in 2004 than they were between 1990 and 1998 (Figures 2-6 and 2-12). In addition, the 2004 collocated surface (surface to 10 cm) and subsurface sample results can be compared (Figure 2-8). In all cases, total PCBs in the surface sample are less than the concentrations in the top interval (0–2 feet) of the collocated core. These decreasing PCB concentrations over time and throughout the slip may be the result of reduced PCB input due to source control, and physical processes

Table 2-6. Concentrations of Detected Chemicals other than PCBs that Exceed SMS in Slip 4 Sediments.

Chemical	Station	Sample Depth (cm)	Concentration	SQS EF[a]	CSL EF[b]
Organics					
Bis(2-ethylhexyl) phthalate	SG06	0 - 10	102 mg/kg, OC	2.174	1.310
Bis(2-ethylhexyl) phthalate	SG06FR (SG41)[c]	0 - 10	132 mg/kg, OC	2.808	1.692
Bis(2-ethylhexyl) phthalate	SG16	0 - 10	51 mg/kg, OC	1.094	0.659
Indeno(1,2,3-cd)pyrene	SG06FR (SG41)	0 - 10	35 mg/kg, OC	1.035	0.400
Phenol	SG16	0 - 10	480 ug/kg	1.143	0.400
Metals					
Mercury	SC01	0 - 61	10.3 mg/kg	25.122	17.458
Mercury - reanalysis	SC01	0 - 61	0.99 mg/kg	2.415	1.678
Mercury	SC02	122 - 183	0.51 mg/kg	1.244	0.864
Mercury	SC02	183 - 244	0.82 mg/kg	2.000	1.390
Mercury	SC04	122 - 183	0.71 mg/kg	1.732	1.203
Mercury	SC04	183 - 244	0.49 mg/kg	1.195	0.831
Mercury	SC07	61 - 122	0.47 mg/kg	1.146	0.797
Silver	SC02	183 - 244	6.4 mg/kg	1.049	1.049

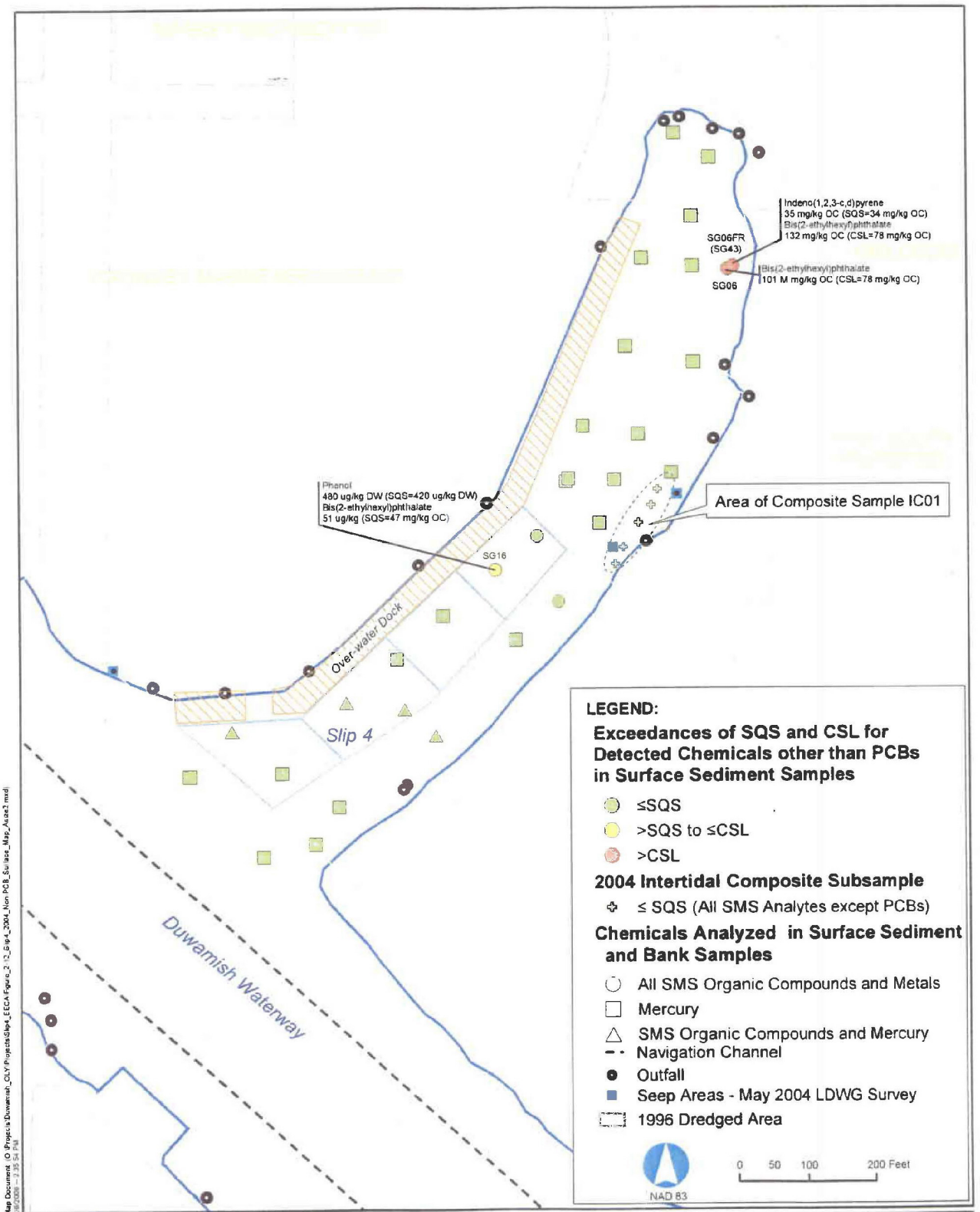
8 locations sampled

4 locations sampled

[a] SQS Exceedance Factor = sample concentration/SQS.

[b] CSL Exceedance Factor = sample concentration/CSL.

[c] FR indicates field replicate sample. Field replicates are additional field samples collected at a station after obtaining the primary or normal sample and repositioning the sampling vessel.



integral

Map Feature Sources
King County GIS Seattle Public Utilities,
USACE Ecology Windward Environmental
David Evans Inc and others
Sediment Chemistry
Lower Duwamish Project Database and 2004
Slip 4 Survey PCB analysis results

M=Mean of Field Duplicate
(i.e., split)
FR=Field Replicate

Figure 2-12
Exceedances of SQS and CSL for Detected Chemicals other than PCBs in Surface Sediment Samples Collected in 2004

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Appendix B
Summary of City of Seattle and King County Source Control Activities in the Slip 4 Drainage Basin

Concentrations of PAH compounds exceeded the SQS in only one of the two split samples at MH229A and MH221A

BEHP concentrations in the Slip 4 inline sediment samples (180–2,200 µg/kg DW) were relatively low compared to other source sediment samples collected in the Lower Duwamish Waterway (<20–26,000 µg/kg DW). However, samples from three of the five locations (MH221A, MH363, and MH229A) exceeded the SQS.

PCBs were detected at four of the five inline sample locations (0.31–31 mg/kg DW), exceeding the SQS at one location (MH100) and the CSL at three locations (MH221A, MH363, and MH229A). MH363 contained the highest concentration of PCBs (31 mg/kg DW or 2,793 mg/kg OC), consisting of Aroclor 1254, although the detection limits for other Arcolors in this sample were relatively high (0.47–3.8 mg/kg DW or 42–342 mg/kg OC). Aroclors 1254 (0.15–3.7 mg/kg DW, 3–96 mg/kg OC) and 1260 (0.16–1.9 mg/kg DW, 4–53 mg/kg OC) were present in the other three locations where PCBs were detected.

2.2.3 Catch Basins and Other Source Sediment Samples

SPU has collected sediment samples from eight catch basins and one upland site drainage ditch in the Slip 4 drainage basin (Figure B-1):

- **CB37**: Located on the Crowley property and drains directly to Slip 4
- **CB44**: Located in a parking area on S. Myrtle Street that drains to the Georgetown flume
- **CB45 and CB46**: Located at the King County maintenance facility on the north end of the airport. CB45 drains to the I-5 SD, and CB46 drains to the King County Airport SD #3/PS44 EOF
- **CB48**: Located on the west side of the Georgetown Steam Plant and drains to the Georgetown flume
- **CB79 and CB80:** Oil/water separator and catch basin, respectively. Both are located on Emerald Services property at head of Slip 4. CB79 drains directly to Slip 4, and CB80 drains to the combined sewer on E. Marginal Way South.
- **RCB49**: Located on S. Webster Street on the east side of Slip 4 and drains to the combined sewer on E. Marginal Way South.
- **S1**: Drainage ditch on Emerald Services property and drains to Slip 4. Results for this soil sample are discussed in Section 2.3.2.2 of the main text.

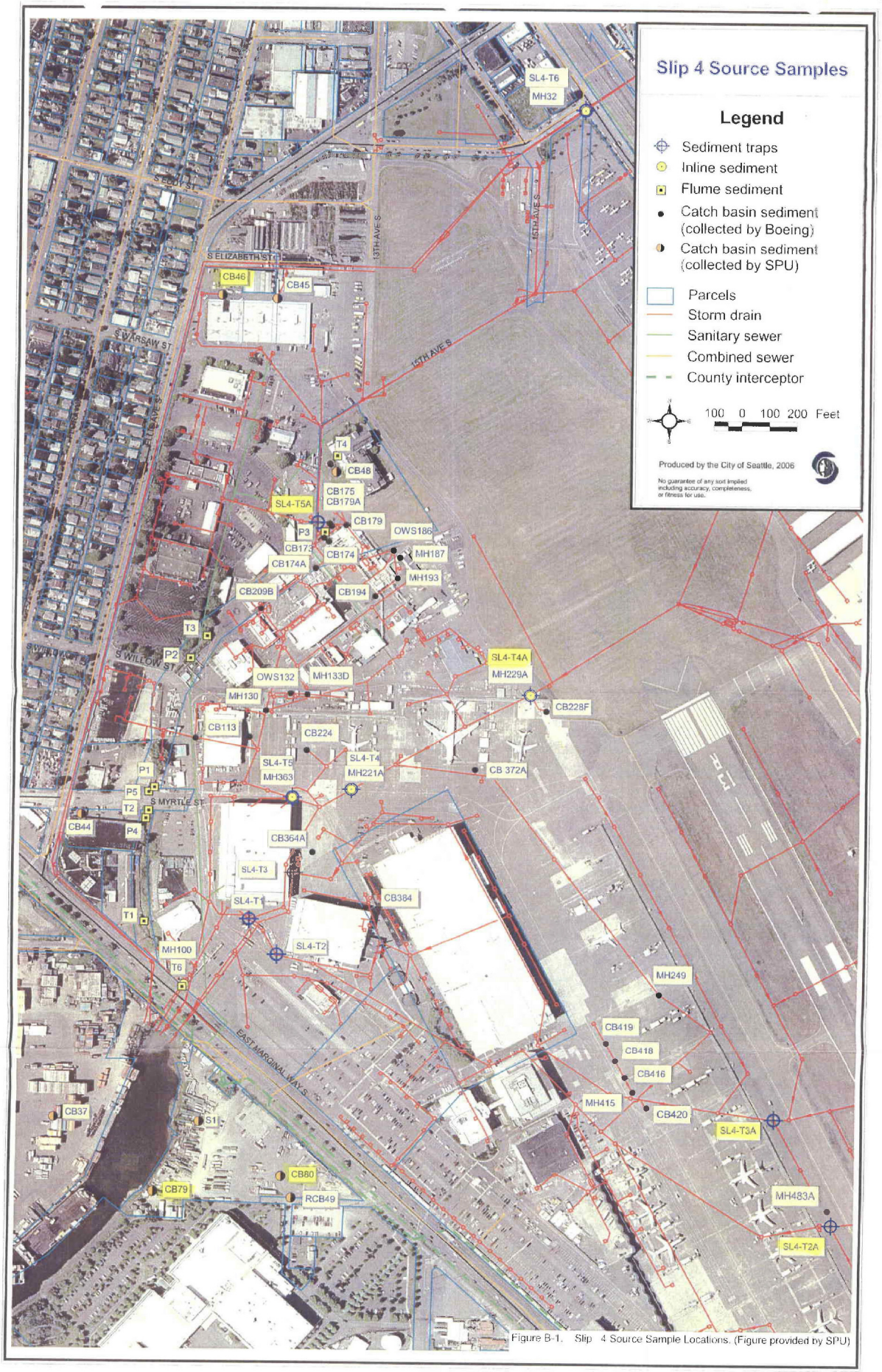

Figure B-1. Slip 4 Source Sample Locations. (Figure provided by SPU)

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Table B-2a: Slip 4 Drainage Basin Sediment Trap Results (mg/kg DW).

	Round 1	Round 1	Round 1	Round 1	Round 1	Round 1	Round 1	Round 1	Round 1	Round 1
Date deployed		03/10/05	03/07/05	03/10/05	03/07/05	03/08/05	03/08/05	03/08/05	03/07/05	
Date removed	08/11/05	08/11/05	08/11/05	08/11/05	08/11/05	08/11/05	08/11/05	08/11/05	08/11/05	08/11/05
Sample collected by	Boeing	SPU	Boeing	SPU	Boeing	Boeing	Boeing	Boeing	Boeing	SPU
TOC (percent)	4.29	NA	NA	NA	NA	5.35	NA	NA	NA	3.17
Metals (mg/kg DW)										
As	11	NA	NA	NA	NA	16	NA	14	21	11
Cu	83.6	NA	NA	NA	NA	94.3	NA	113	148	84.5
Pb	140	NA	NA	NA	NA	144	NA	962	109	110
Hg	1.10	NA	NA	NA	NA	0.19	NA	0.66	1.12	0.10
Zn	368	NA	NA	NA	NA	450	NA	220	[redacted]	[redacted]
LPAH (ug/kg DW)										
Acenaphthene	210	NA	NA	NA	NA	160 U	1,300	110 U	130 U	79 U
Acenaphthylene	100 U	NA	NA	NA	NA	160 U	210 U	110 U	130 U	79 U
Anthracene	360	NA	NA	NA	NA	180	1,500	150	210	98
Fluorene	190	NA	NA	NA	NA	160 U	1,000	110 U	130 U	79 U
Naphthalene	100 U	NA	NA	NA	NA	160 U	670	110 U	130 U	79 U
Phenanthrene	2,800	NA	NA	NA	NA	1,700	8,600	1,300	1,600	570
HPAH (ug/kg DW) 17,598										
Benzo(a)anthracene	1,400	NA	NA	NA	NA	860	3,000	840	940	270
Benzo(a)pyrene	1,700	NA	NA	NA	NA	1,400	3,400	1,100	1,200	350
Benzo(b)fluoranthene	2,400	NA	NA	NA	NA	2,100	4,600	1,600	1,700	380
Benzo(k)fluoranthene	1,300	NA	NA	NA	NA	1,300	2,600	890	970	220
Benzo(g,h,i)perylene	720	NA	NA	NA	NA	710	1,600	450	600	79 U
Chrysene	1,900	NA	NA	NA	NA	1,700	4,100	1,200	1,400	370
Dibenzo(a,h)anthracene	260	NA	NA	NA	NA	160 U	730	110 U	130 U	79 U
Fluoranthene	4,100	NA	NA	NA	NA	3,100	8,900	2,400	2,900	880
Indeno(1,2,3-c,d)pyrene	810	NA	NA	NA	NA	780	1,900	520	680	84
Pyrene	3,000	NA	NA	NA	NA	2,100	6,800	1,700	2,000	630
Phthalates (ug/kg DW)										
Bis(2-ethylhexyl)phthalate	2,400	NA	NA	NA	NA	2,600	6,000	1,800	2,700	6,000
Butylbenzylphthalate	120	NA	NA	NA	NA	160 U	210 U	110 U	140	420
Diethylphthalate	100 U	NA	NA	NA	NA	160 U	210 U	110 U	130 U	79 U
Dimethylphthalate	100 U	NA	NA	NA	NA	160 U	210 U	110 U	130 U	79 U
Di-n-butylphthalate	130	NA	NA	NA	NA	350	260	150	130 U	460
Di-n-octylphthalate	440	NA	NA	NA	NA	4,300	3,700	220	1,200	430
PCBs (ug/kg DW)										
Aroclor 1016	29 U	48 U	21 U	34 U	20 U	9.8 U	9.8 U	9.6 U	49 U	1,800 U
Aroclor 1242	29 U	48 U	21 U	34 U	20 U	9.8 U	9.8 U	9.6 U	49 U	1,800 U
Aroclor 1248	29 U	48 U	21 U	34 U	20 U	9.8 U	9.8 U	9.6 U	49 U	1,800 U
Aroclor 1254	10,000	67	500 P	38 JP	1,400	290 P	1,900 P	72	24,000	7,800
Aroclor 1260	1,200 U	110	340	34 U	380 U	160	850	34	2,400 U	1,800 U
Aroclor 1221	29 U	48 U	21 U	34 U	20 U	9.8 U	9.8 U	9.6 U	49 U	1,800 U
Aroclor 1232	29 U	48 U	21 U	34 U	20 U	9.8 U	9.8 U	9.6 U	49 U	1,800 U
Total PCBs	10,000	177	840 P	38 JP	1,400	450 P	2,750 P	106	24,000	[redacted]
TPH (mg/kg)										
Diesel	230	NA	NA	NA	NA	100	NA	160	390	310
Motor Oil	970	NA	NA	NA	NA	410	NA	570	1,400	800

Detected values shown in bold type.
NA = not analyzed
U = Chemical not detected at reported concentration
J = Chemical concentration is reported as estimate.
P = Chemical detected on both chromatographic columns, but values differ by >40% RPD with no obvious interference.
Exceeds SQS (0.41 mg/kg mercury, 410 mg/kg zinc) or MTCA Method A soil cleanup level for unrestricted use (1 mg/kg PCBs)
Exceeds CSL (0.59 mg/kg mercury) or MTCA Method A soil cleanup level for industrial use (10 mg/kg PCBs)

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HCIA ID: CB1802

Table B-4a: Slip 4 drainage basin catch basin and sediment sample results (dry weight).

	SQS	CSL	CB37	CB44	CB45	CB46	CB48	CB79	CB80	RCB49	S1
Date			6/22/04	12/8/04	12/22/04	12/22/04	2/20/05	11/9/05	11/9/05	11/8/05	11/9/05
TOC (percent)			4.74	24.6	9.74	10.4	1.57	6.42	2.68	4.06	3.1
Metals (mg/kg DW)											
As	57	93	20 U	12	20	20	12	30	6 U	20 U	11
Cu	390	390	173	142	6,320	5,660	51.5	207	85.2	85	69.9
Pb	450	530	250	123	481	396	343	114	29	79	73
Hg	0.41	0.59	0.08	0.12	0.30	0.20	0.32	0.2	0.05 U	0.05 U	0.14
Zn	410	960	1,220	524	3,420	3,530	657	758	268	357	172
LPAH (ug/kg DW)						93,000		9,560	1,662		
Acenaphthene			170	140 U	760	1,600 U	130	90 U	66	20 U	35 U
Acenaphthylene			140 U	140 U	390 U	1,600 U	59 U	90 U	42 U	20 U	35 U
Anthracene			820	140 U	2,100	5,000	110	6,400	67 M	16 J	21 J
Fluorene			350	140 U	1,300	3,000	130	1,300	340	20 U	35 U
Naphthalene			140 U	140 U	390 U	1,600 U	470	160	89	20 U	35 U
Phenanthrene			3,000	220	17,000	35,000	3,100	1,700	1,100	68	78
HPAH (ug/kg DW)						344,400		13,990	2,782		
Benzo(a)anthracene			610	140 U	13,000	27,000	1,300	730	160	60	81
Benzo(a)pyrene			200	140 U	15,000	32,000	1,400	830	170	120	140
Benzo(b)fluoranthene			480	180	15,000	34,000	3,100	1,200	250 M	200	250
Benzo(k)fluoranthene			320	180	15,000	34,000	1,500	1,300	240 M	170	190
Benzofluoranthenes			800	360	30,000	~~68,000~~	4,600	~~2,580~~	~~490 M~~	370	440
Benzo(g,h,i)perylene			140 U	140 U	7,300	16,000	660	570	140	110	87
Chrysene			1,000	290	20,000	43,000	2,100	1,800	400	120	160
Dibenzo(a,h)anthracene			140 U	140 U	2,700	5,400	99	150	42 U	14 J	35
Fluoranthene			3,600	410	31,000	85,000	4,700	1,700	360	180	190
Indeno(1,2,3-c,d)pyrene			140 U	140 U	8,600	19,000	940	410	62	41	61
Pyrene			2,600	290	23,000	49,000	3,100	5,300	1,000	180	290
Phthalates (ug/kg DW)											
Bis(2-ethylhexyl)phthalate			1,600	3,910	8,800	30,000	88	120,000	38,000	1,400	5,500
Butylbenzylphthalate			1,300	430	490	1,600 U	59 U	90 U	1,800	1,100	140
Diethylphthalate			140 U	140 U	390 U	1,600 U	59 U	90 U	42 U	20 U	35 U
Dimethylphthalate			280	850	620	1,600 U	59 U	90 U	1,900	44	35 U
Di-n-butylphthalate			140 U	140 U	1,200	1,600 U	59 U	90 U	360 B	54 B	63 B
Di-n-octylphthalate			140 U	140 U	1,200	1,600 U	59 U	4,000	1,800	79	35 U
PCBs (ug/kg DW)											
Aroclor 1016			20 U	20 U	58 U	47 U	19 U	99 U	98 U	98 U	99 U
Aroclor 1242			20 U	20 U	58 U	47 U	19 U	99 U	98 U	98 U	99 U
Aroclor 1248			20 U	20 U	58 U	47 U	19 U	99 U	98 U	98 U	99 U
Aroclor 1254			20 U	49 Y	170	250	250	160	98 U	98 U	99 U
Aroclor 1260			20 U	180	300	430	77 Y	140	98 U	98 U	99 U
Aroclor 1221			20 U	20 U	58 U	47 U	19 U	99 U	98 U	98 U	99 U
Aroclor 1232			20 U	20 U	58 U	47 U	19 U	99 U	98 U	98 U	99 U
Total PCBs			20 U	180	470	680	250	300	98 U	98 U	99 U
TPH (mg/kg)											

Table B-4a: Slip 4 drainage basin catch basin and sediment sample results (dry weight).

	SQS	CSL	CB37	CB44	CB45	CB46	CB48	CB79	CB80	RCB49	S1
Diesel			180	85	950	1,900	98	6,000	1,200	68	280
Motor Oil			650	790	4,700	4,600	210	13,000	2,300	450	1,500

Detected values shown in bold type.

U = Chemical not detected at reported concentration

Y = Chemical not detected at the reported concentration. Reporting limit raised due to chromatograhic interference.

P = Chemical detected on both chromatographic columns, but values differ by >40% RPD with no obvious interference.

M = Estimated value. Analyte detected and confirmed by analyst, but spectral match patterns are low

Exceeds SQS

Exceeds CSL or MTCA Method A soil cleanup level

Table B-4b: Slip 4 drainage basin catch basin and sediment samples compared to Sediment Management Standards.

	SQS	CSL	CB37	CB44	CB45	CB46	CB48	CB79	CB80	RCB49	S1
Date			6/22/04	12/8/04	12/22/04	12/22/04	2/20/05	11/9/05	11/9/05	11/8/05	11/9/05
TOC (percent)			4.74	24.6	9.74	10.4	1.57	6.42	2.68	4.06	3.1
Metals (mg/kg DW)											
As	57	93	20 U	12	20	20	12	30	6 U	20 U	11
Cu	390	390	173	142	6,320	5,660	52	207	85.2	85	69.9
Pb	450	530	250	123	481	396	343	114	29	79	73
Hg	0.41	0.59	0.08	0.12	0.30	0.20	0.32	0.2	0.05 U	0.05 U	0.14
Zn	410	960	1,220	524	3,420	3,530	657	758	268	357	172
LPAH (mg/kg OC)											
Acenaphthene	16	57	4	1 U	8	15 U	8	1 U	2	0.5 U	1 U
Acenaphthylene	66	66	3 U	1 U	4 U	15 U	4 U	1 U	2 U	0.5 U	1 U
Anthracene	220	1,200	17	1 U	22	48	7	100	3 M	0.4 J	1 J
Fluorene	23	79	7	1 U	13	29	8	20	13	0.5 U	1 U
Naphthalene	99	170	3 U	1 U	4 U	15 U	30	2	3	0.5 U	1 U
Phenanthrene	100	480	63	1	175	337	197	26	41	2	3
HPAH (mg/kg OC)											
Benzo(a)anthracene	110	270	13	1 U	133	260	83	11	6	1	3
Benzo(a)pyrene	99	210	4	1 U	154	308	89	13	6	3	5
Benzo(b)fluoranthene	---	---	10	1	154	327	197	19	9 M	5	8
Benzo(k)fluoranthene	---	---	7	1	154	327	96	20	9 M	4	6
Benzo(b+k)fluoranthenes	230	450	17	1	308	654	293	39	18 M	9	14
Benzo(g,h,i)perylene	31	78	3 U	1 U	75	154	42	9	5	3	3
Chrysene	110	460	21	1	205	413	134	28	15	3	5
Dibenzo(a,h)anthracene	12	33	3 U	1 U	28	52	6	2	2 U	0 J	1
Fluoranthene	160	1,200	76	2	318	817	299	26	13	4	6
Indeno(1,2,3-c,d)pyrene	34	88	3 U	1 U	88	183	60	6	2	1	2
Pyrene	1,000	1,400	55	1	236	471	197	83	37	4	9
Phthalates (mg/kg OC)											
Bis(2-ethylhexyl)phthalate	47	78	34	16	90	288	6	1,869	1,418	34	177
Butylbenzylphthalate	5	64	27	2	5	15 U	4 U	1 U	67	27	5
Diethylphthalate	61	110	3 U	1 U	4 U	15 U	4 U	1 U	2 U	0.5 U	1 U
Dimethylphthalate	53	53	6	3	6	15 U	4 U	1 U	71	1	1 U
Di-n-butylphthalate	220	1,700	3 U	1 U	12	15 U	4 U	1 U	13 B	1 B	2 B
Di-n-octylphthalate	58	4,500	3	1	12	15	4	62	67	2	1 U
PCBs (mg/kg OC)											
Aroclor 1016			0.4 U	0.1 U	0.6 U	0.5 U	1.2 U	1.5 U	3.7 U	2.4 U	3.2 U
Aroclor 1242			0.4 U	0.1 U	0.6 U	0.5 U	1.2 U	1.5 U	3.7 U	2.4 U	3.2 U
Aroclor 1248			0.4 U	0.1 U	0.6 U	0.5 U	1.2 U	1.5 U	3.7 U	2.4 U	3.2 U
Aroclor 1254			0.4 U	0.2 Y	1.7	2.4	15.9	2.5	3.7 U	2.4 U	3.2 U
Aroclor 1260			0.4 U	0.7	3.1	4.1	4.9 Y	2.2	3.7 U	2.4 U	3.2 U
Aroclor 1221			0.4 U	0.1 U	0.6 U	0.5 U	1.2 U	1.5 U	3.7 U	2.4 U	3.2 U
Aroclor 1232			0.4 U	0.1 U	0.6 U	0.5 U	1.2 U	1.5 U	3.7 U	2.4 U	3.2 U
Total Aroclor	12	65	0.4 U	0.7	4.8	6.5	15.9	4.7	3.7 U	2.4 U	3.2 U
TPH (mg/kg)											

Table B-4b: Slip 4 drainage basin catch basin and sediment samples compared to Sediment Management Standards.

	SQS	CSL	CB37	CB44	CB45	CB46	CB48	CB79	CB80	RCB49	S1
Diesel	2,000[a]		**180**	**85**	**950**	**1,900**	**98**	**6,000**	**1,200**	**68**	**280**
Motor Oil	2,000[a]		**650**	**790**	**4,700**	**4,600**	**210**	**13,000**	**2,300**	**450**	**1,500**

Detected values shown in bold type.

[a]MTCA Method A soil cleanup level for unrestricted use.

U = Chemical not detected at reported concentration

Y = Chemical not detected at the reported concentration. Reporting limit raised due to chromatograhic interference.

M = Estimated value. Analyte detected and confirmed by analyst, but spectral match patterns are low.

J = Chemical concentration is reported as estimate

Exceeds SQS

Exceeds CSL or MTCA Method A soil cleanup level